Hazardous chemicals in plastics in marine environments and their potential effects on marine organisms

Hideshige Takada, Kosuke Tanaka, Rei Yamashita

（Tokyo University of Agriculture and Technology）

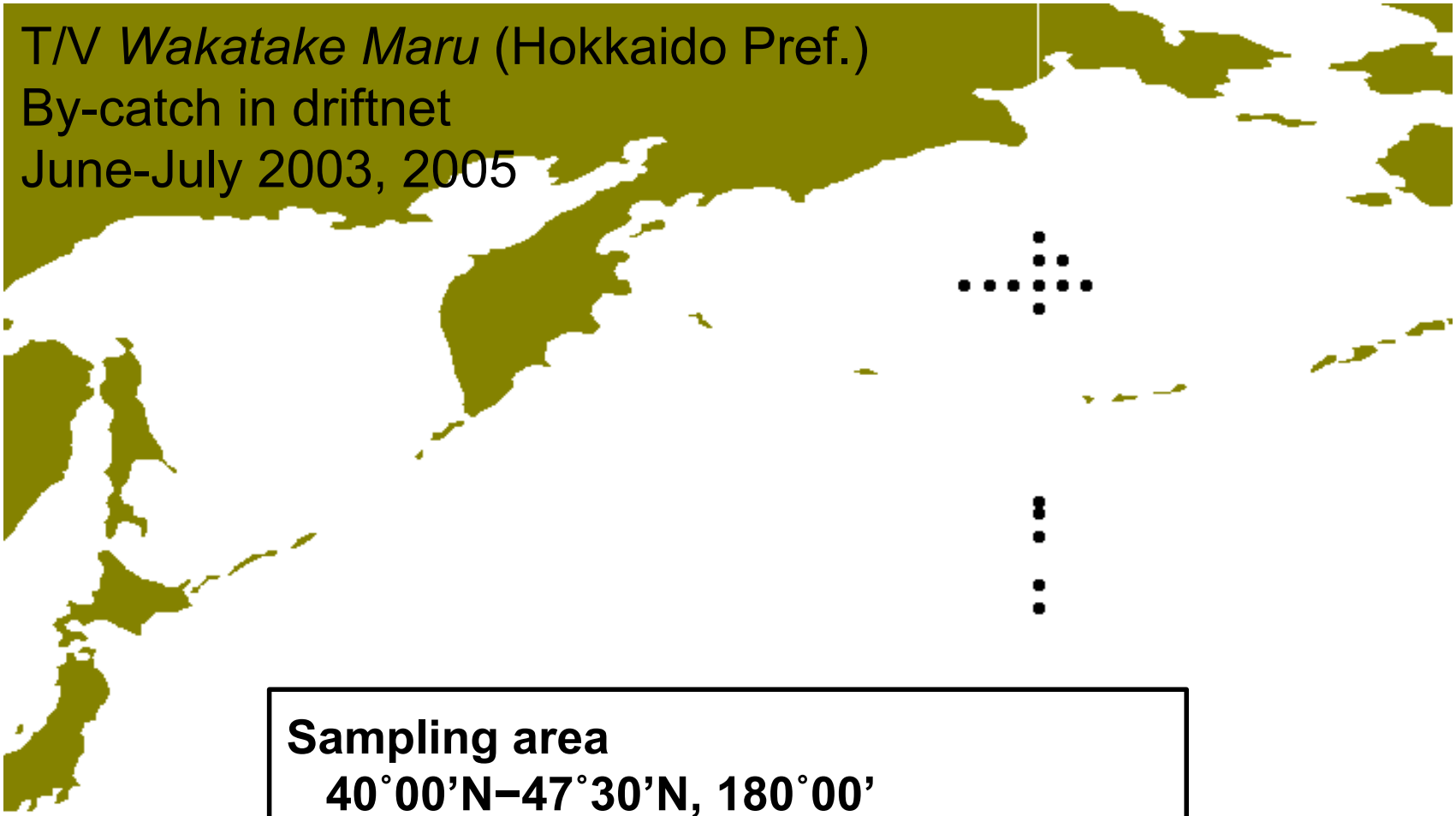
Yutaka Watanuki

（Hokkaido University）

Marine organisms ingest plastics

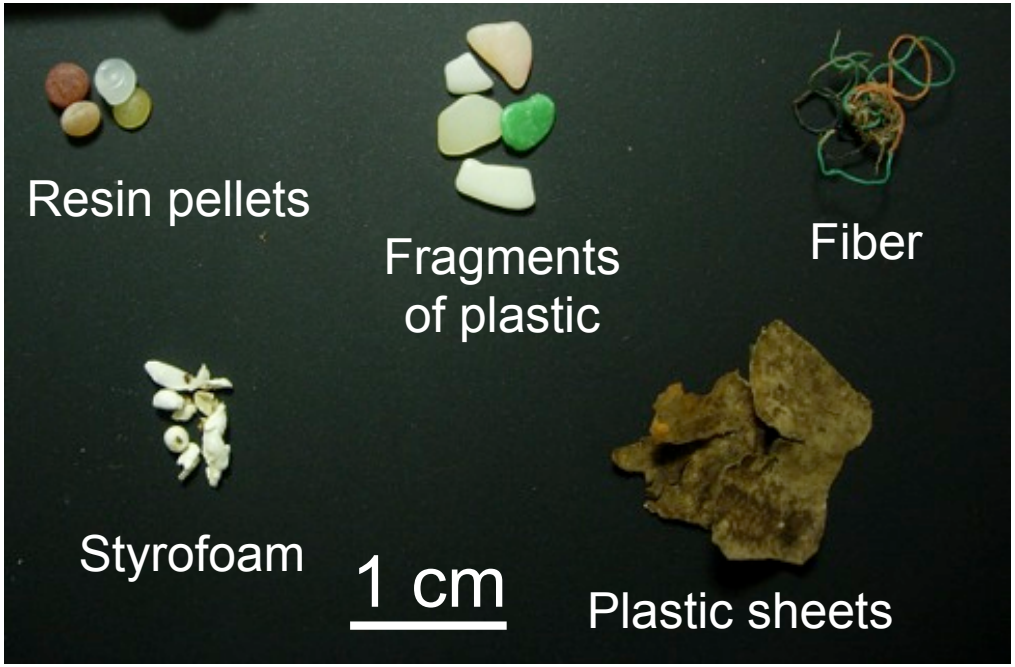
Albatross

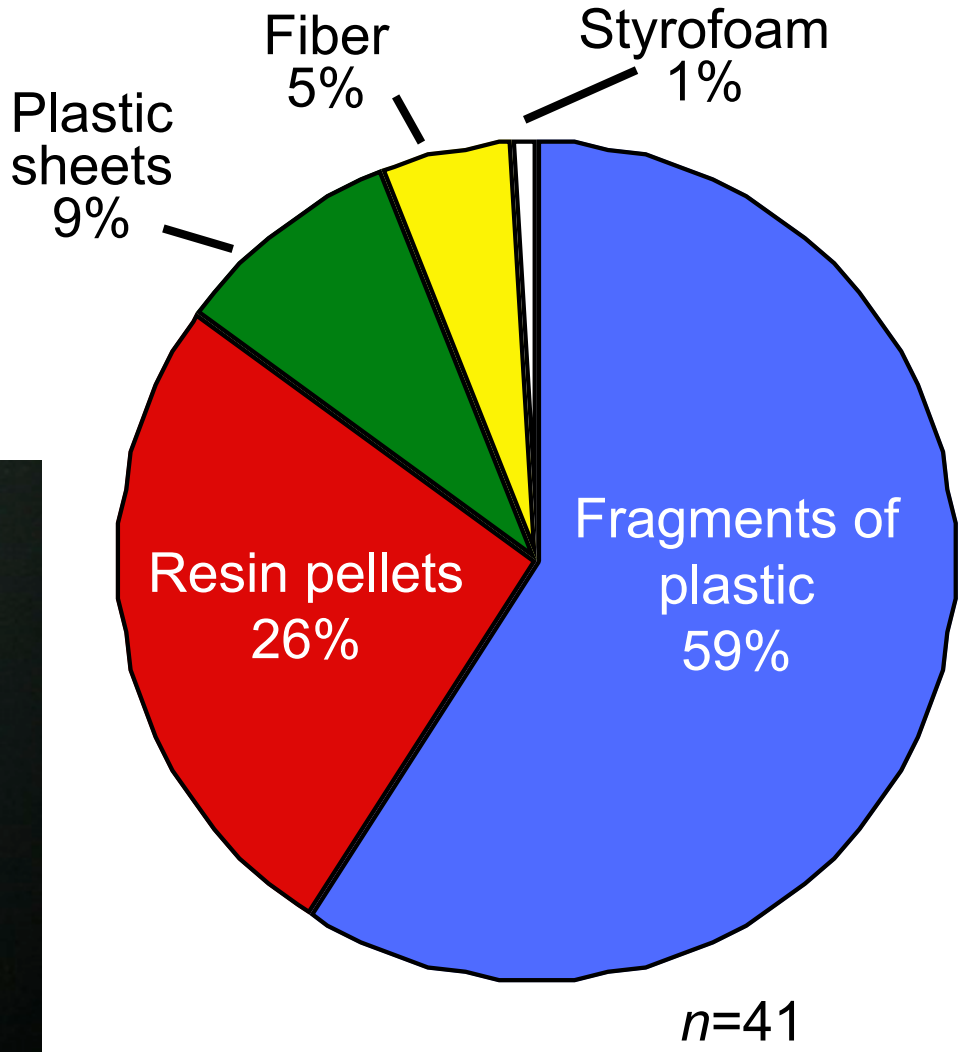
Short-tailed shearwater from Northern pacific



Plastics found in digestive tracts of the seabirds

Short-tailed shearwater
Puffinus tenuirostris





Type and composition of plastics found in the stomachs of short-tailed shearwater.

Yamashita et al. 2011

Plastics detected in digestive tract of short-tailed shearwater

0.1 g – 0.6 g per an individual

Marine organisms ingest plastics

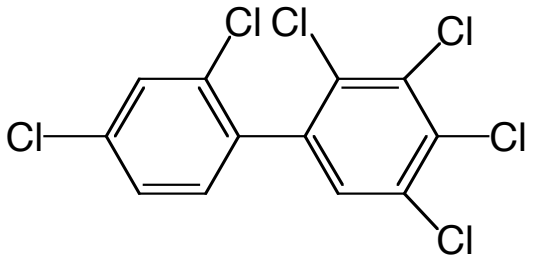
More than 180 species of animals are known to have ingested plastic debris, including birds, fish, turtles and marine mammals.

Physical impacts of the ingested plastics have been reported for many species of organisms (Wright et al., 2013).

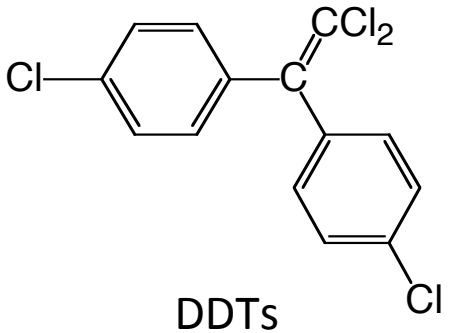
Plastics in Seabird

Plastics carry two types of chemicals in marine environment

Sorption from ambient seawater



Polychlorinated biphenyl (PCBs)



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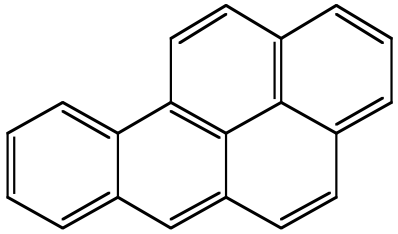
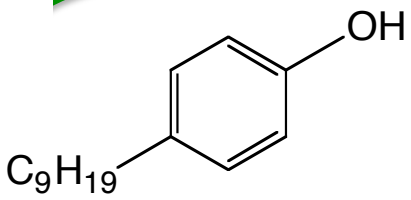
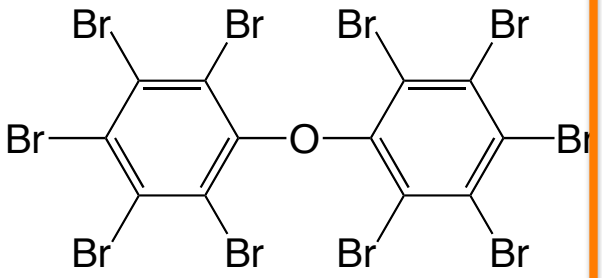


Polycyclic aromatic hydrocarbons (PAHs)

Additive-derived chemicals



Nonylphenol



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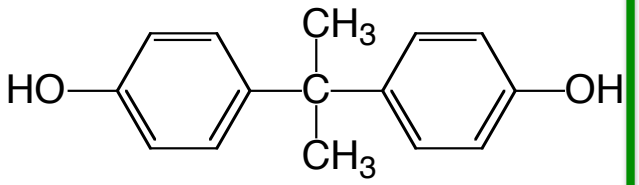
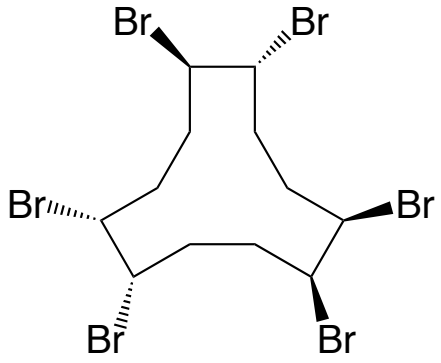
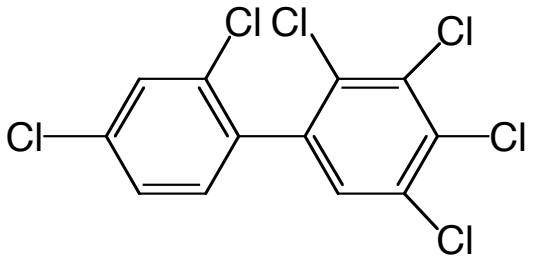


Bisphenol A



Hexabromocyclododecanes (HBCDs)

Plastics carry two types of chemicals in marine environment



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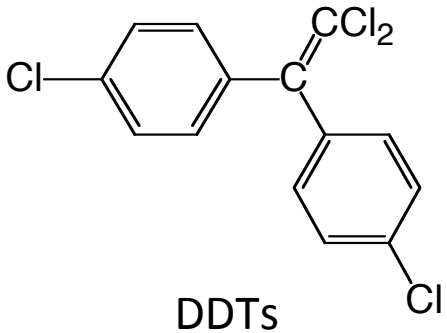

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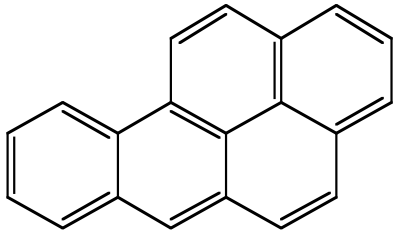

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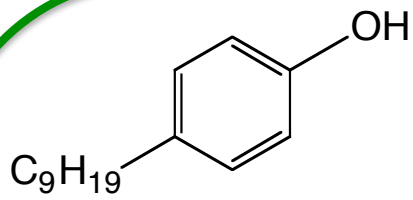

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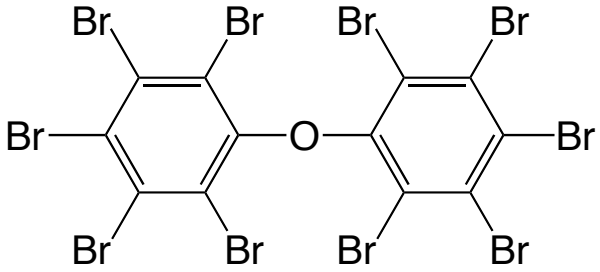

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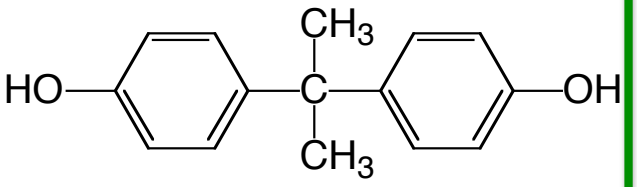
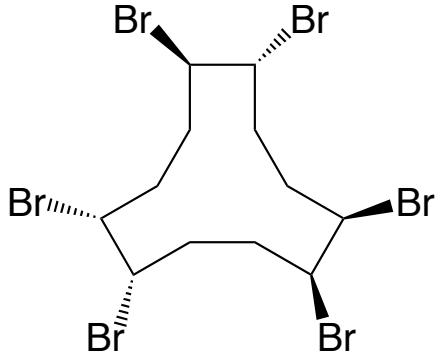
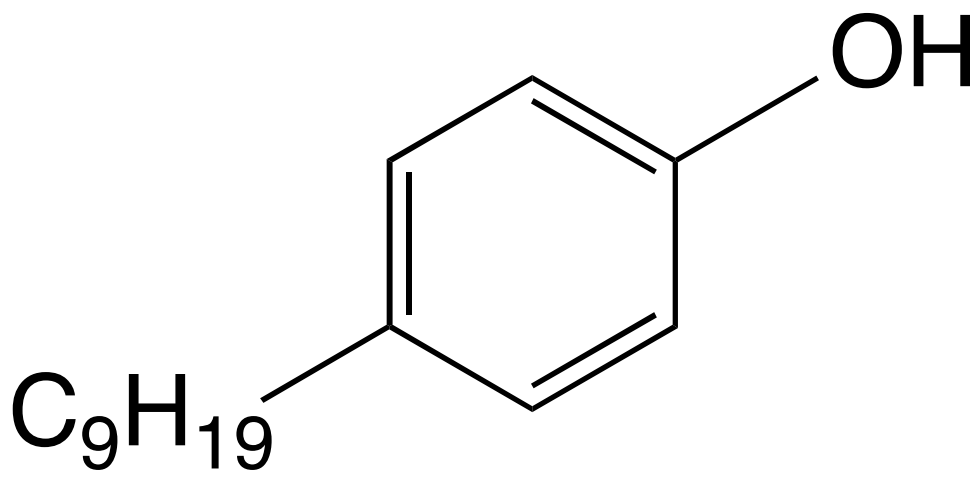


Bisphenol A



Hexabromocyclododecanes (HBCDs)

Nonylphenol : Endocrine disrupting chemicals

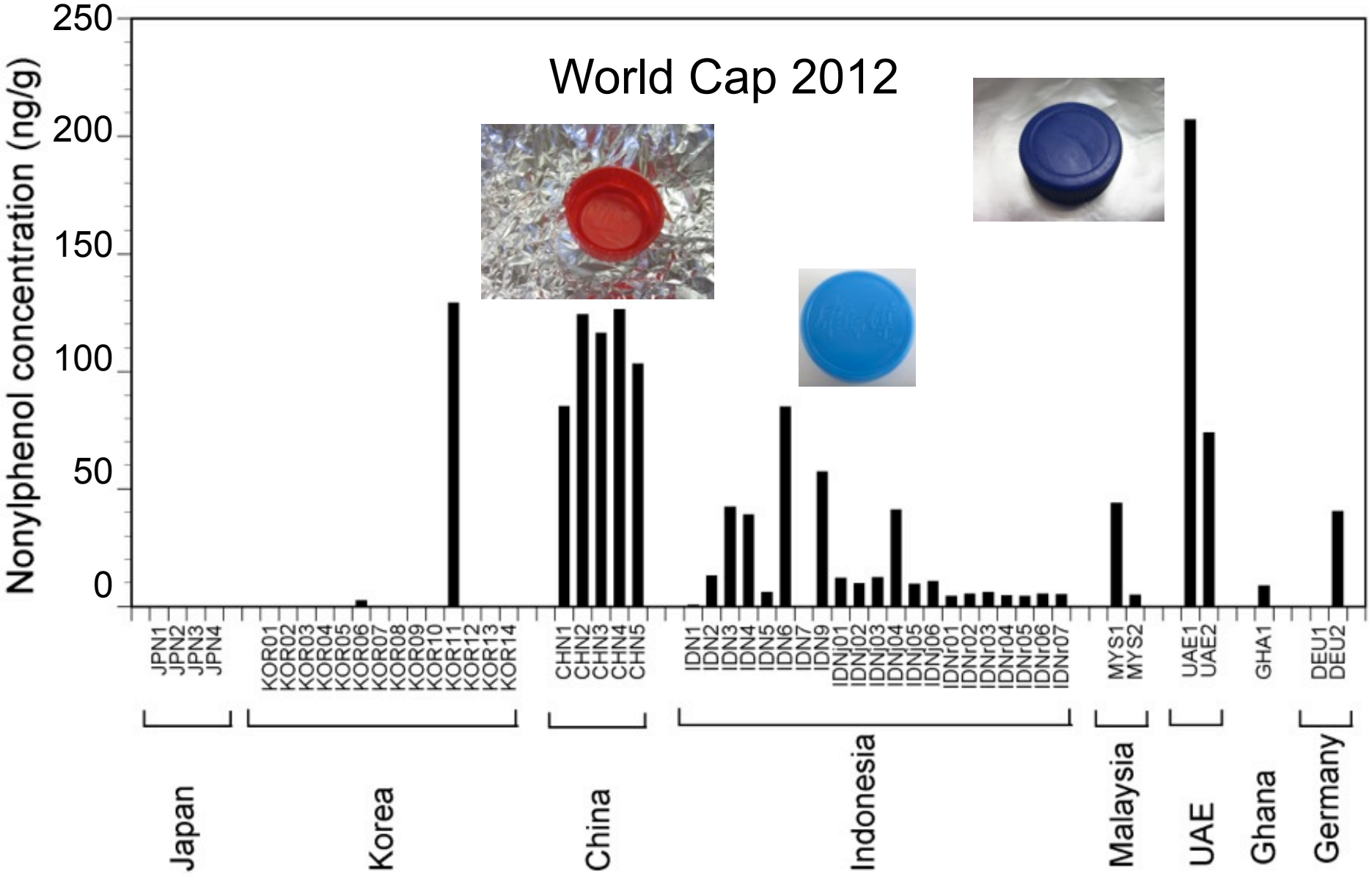


Additives to plastic

Antioxidants
Antistatic agents

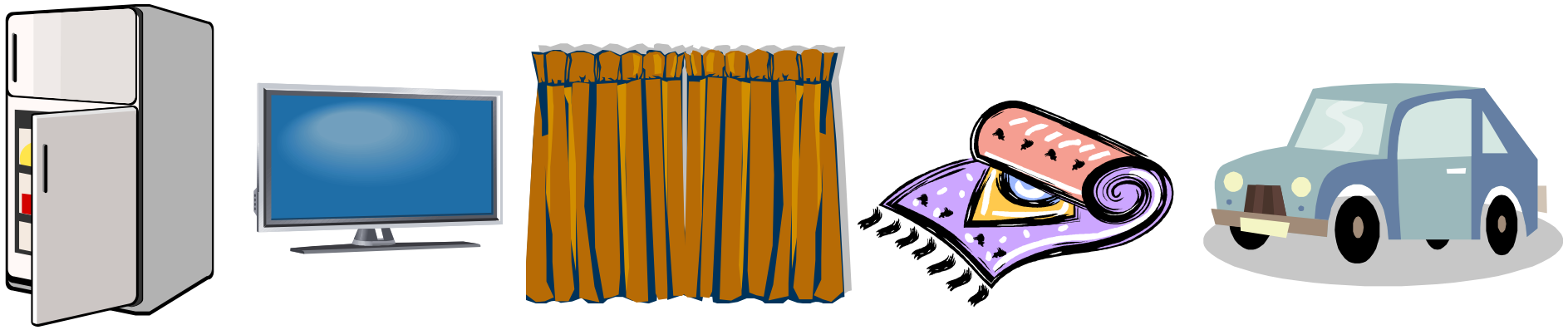
- disorders in the reproductive system
- vaginal clear cell adenocarcinoma
- decreased ability to reproduce

Endocrine disrupting chemicals released from plastic caps of mineral water bottles



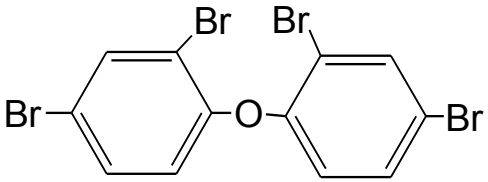
PBDEs : Flame retardants

applied in various electric products and fabrics.



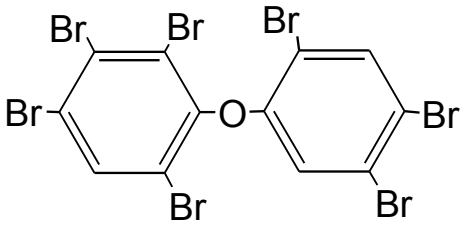
3 technical products (mixtures of congeners)

Penta BDE
(Br4, Br5)



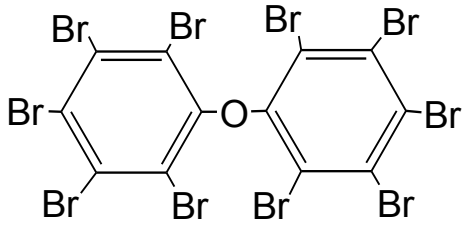
e.g., BDE47

Octa BDE
(Br7,8)



e.g., BDE183

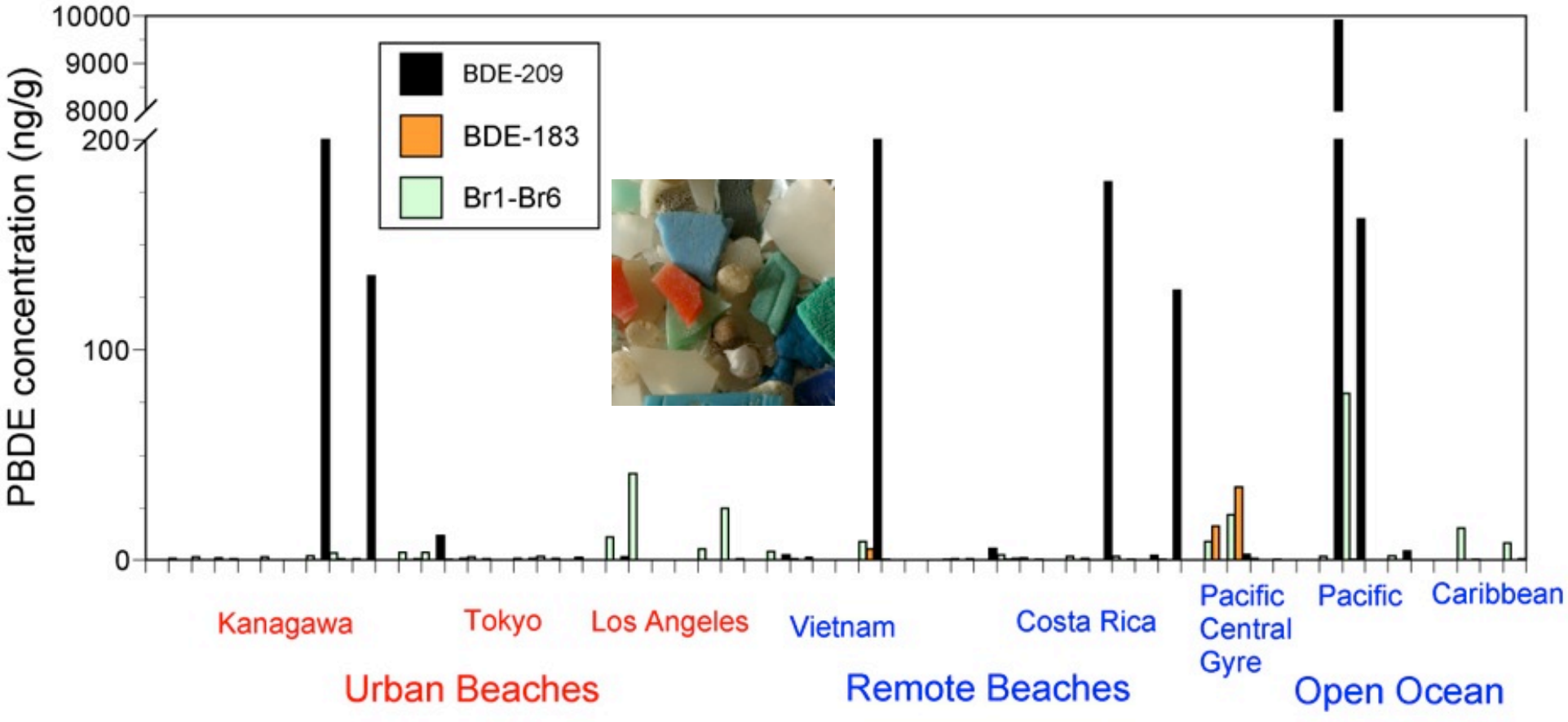
DecaBDE
(Br10)



e.g., BDE209

Sampling locations of user plastic fragments

Distributions of PBDE congeners in marine plastic fragments

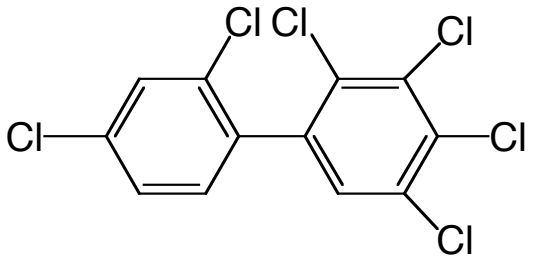


- BDE209 and BDE183 were sporadically detected in marine plastics even from open ocean

Hirai et al., 2011

Plastics carry two types of chemicals in marine environment

Sorption from ambient seawater



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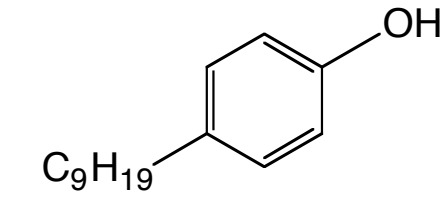

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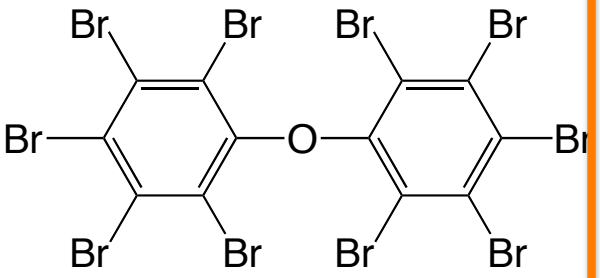

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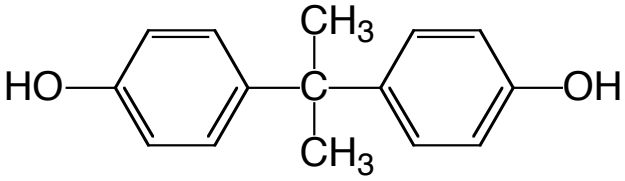

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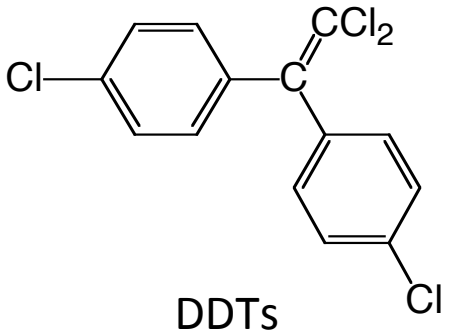

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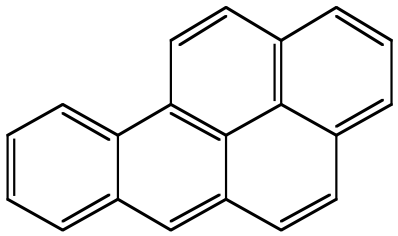

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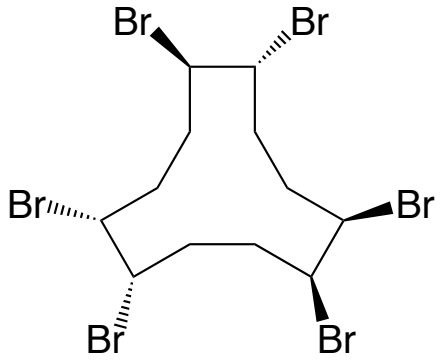
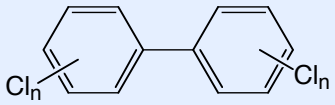


Hexabromocyclododecanes (HBCDs)

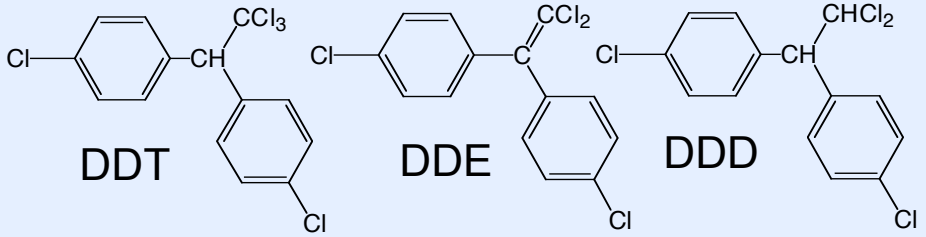
Persistent organic pollutants (POPs)

PCBs



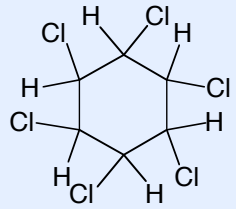
- Industrial products for a variety of uses including dielectric fluid, heat medium, and lubricants.
- Endocrine disrupting chemicals

DDTs



- DDT and its metabolites such as DDE and DDD.
- DDT was used as insecticides
- Endocrine disrupting chemicals

HCH



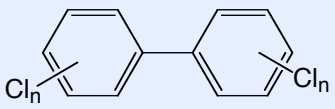
- Insecticide

✓Man-made chemicals
✓Persistent (stable, resistant to degradation)
✓Toxic to human and marine organisms
✓Hydrophobic (lipophilic)
✓Bioaccumulative

Regulated by Stockholm convention

Pellets accumulate POPs from seawater

PCBs



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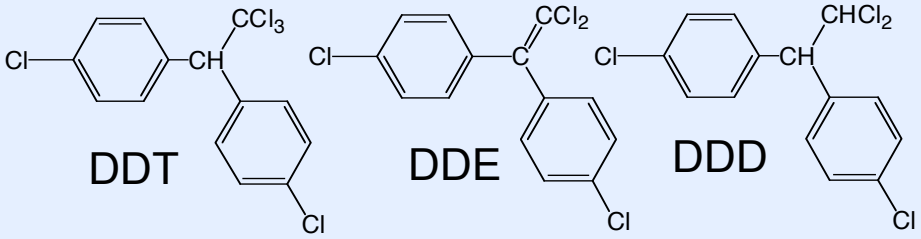

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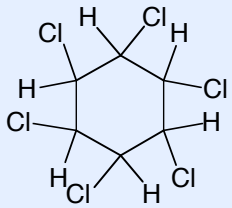
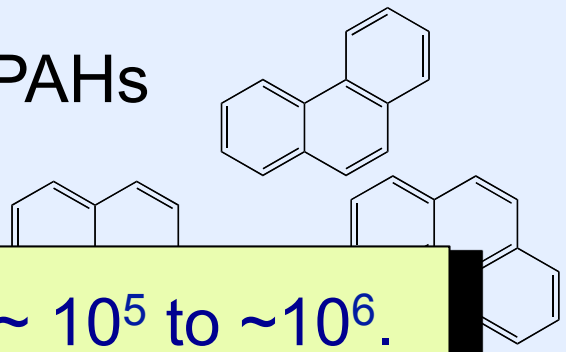
adsorption from ambient seawater

Plastics

HCH



PAHs



Concentration factor is estimated to be ~ 10^5 to ~10^6.

International Pellet Watch

Global Monitoring of Persistent Organic Pollutants (POPs) Using Beached Plastic Resin Pellets

Air Mail

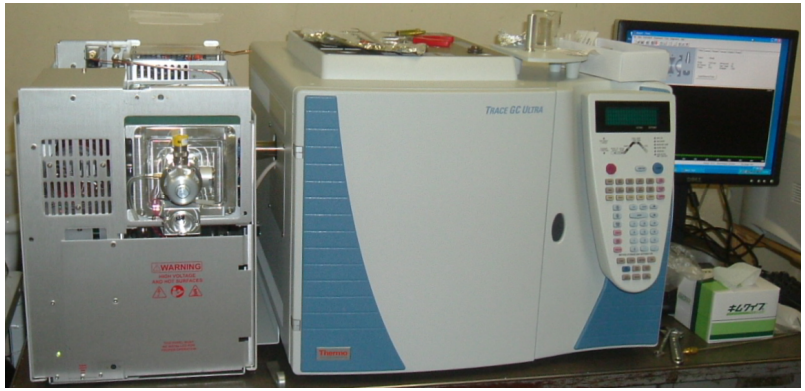
More than 50 pieces (~ 100 pieces)
per one location

Laboratory of Organic Geochemistry, Dr. Hideshige Takada,
Tokyo University of Agriculture and Technology,
Fuchu, Tokyo 183-8509, Japan

Plastic resin pellet from various areas in the world

Analysis for persistent organic pollutants (POPs)

Chemical Analysis

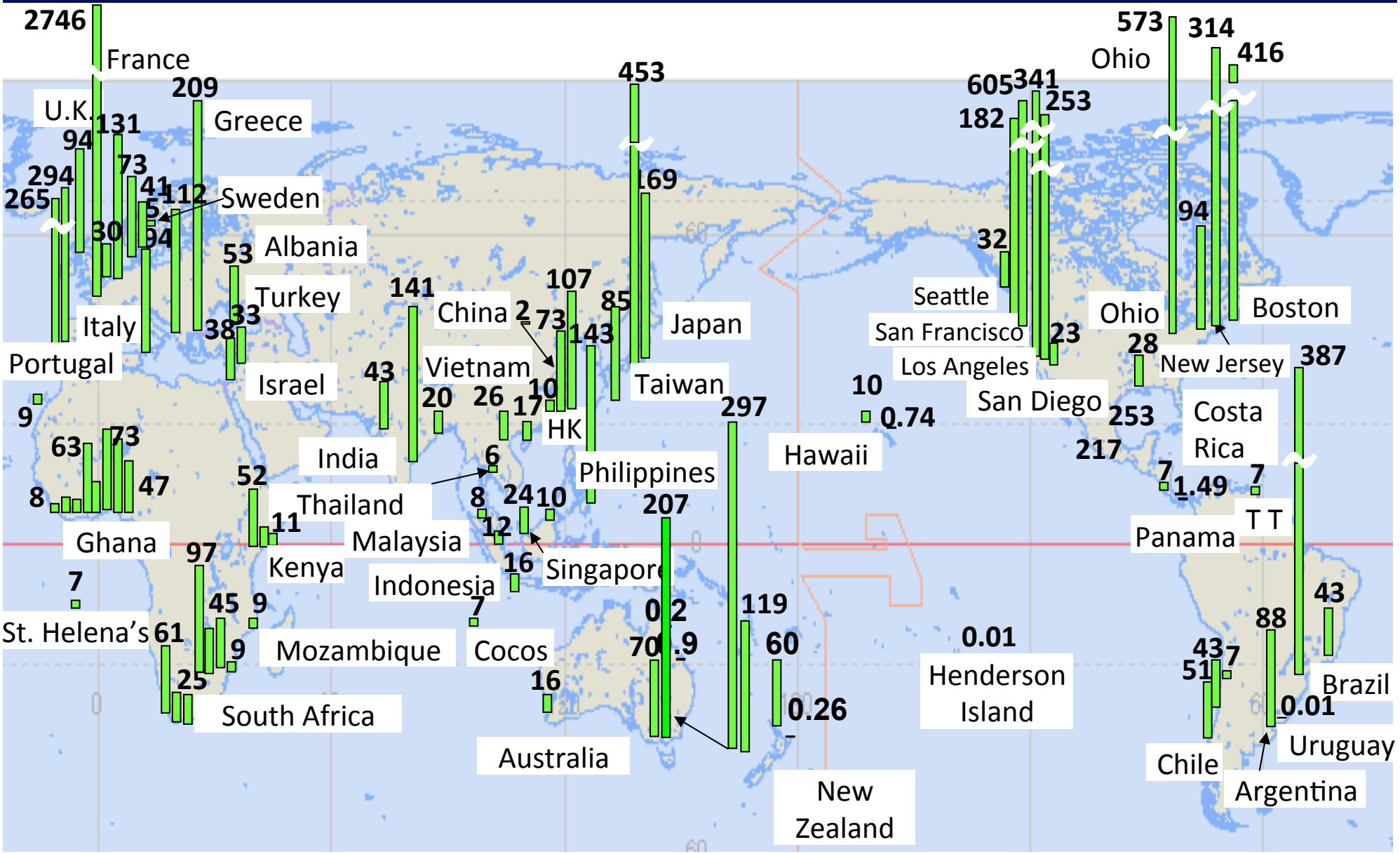


Status of Global pollution

Chemical hazardousness of marine plastics

- **Feed the data** back to the collaborators via e-mail
- **Releasing** the results on **web** http://**www.pelletwatch.org**/

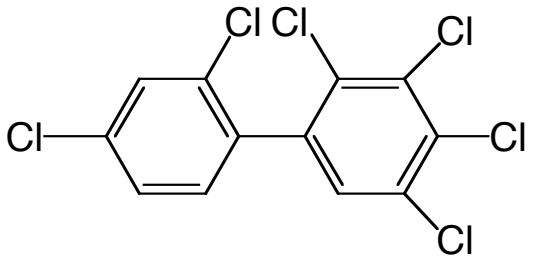
International Pellet Watch : monitoring of POPs
Plastics carry hazardous chemicals in marine environments



Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)

Plastics carry two types of chemicals in marine environment

Sorption from ambient seawater



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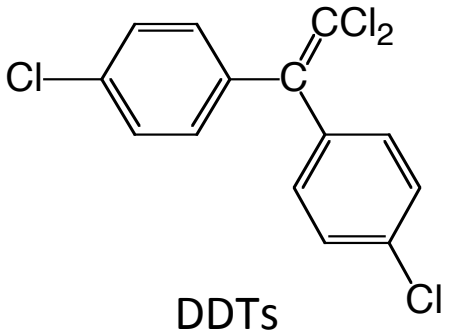

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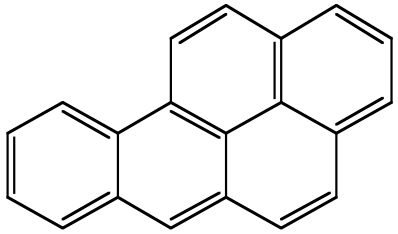

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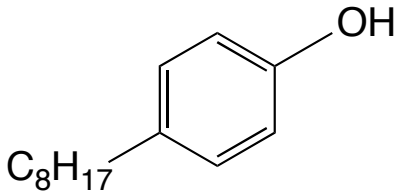
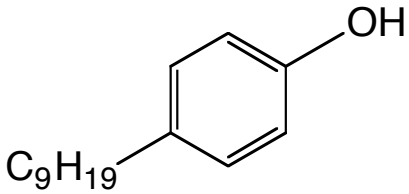


Octylphenol



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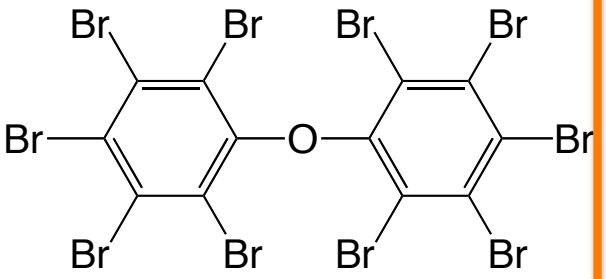

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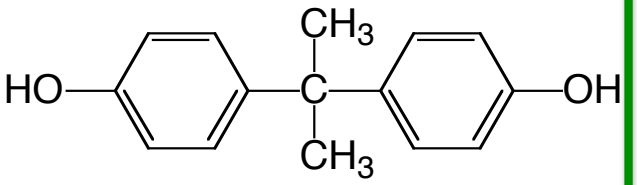
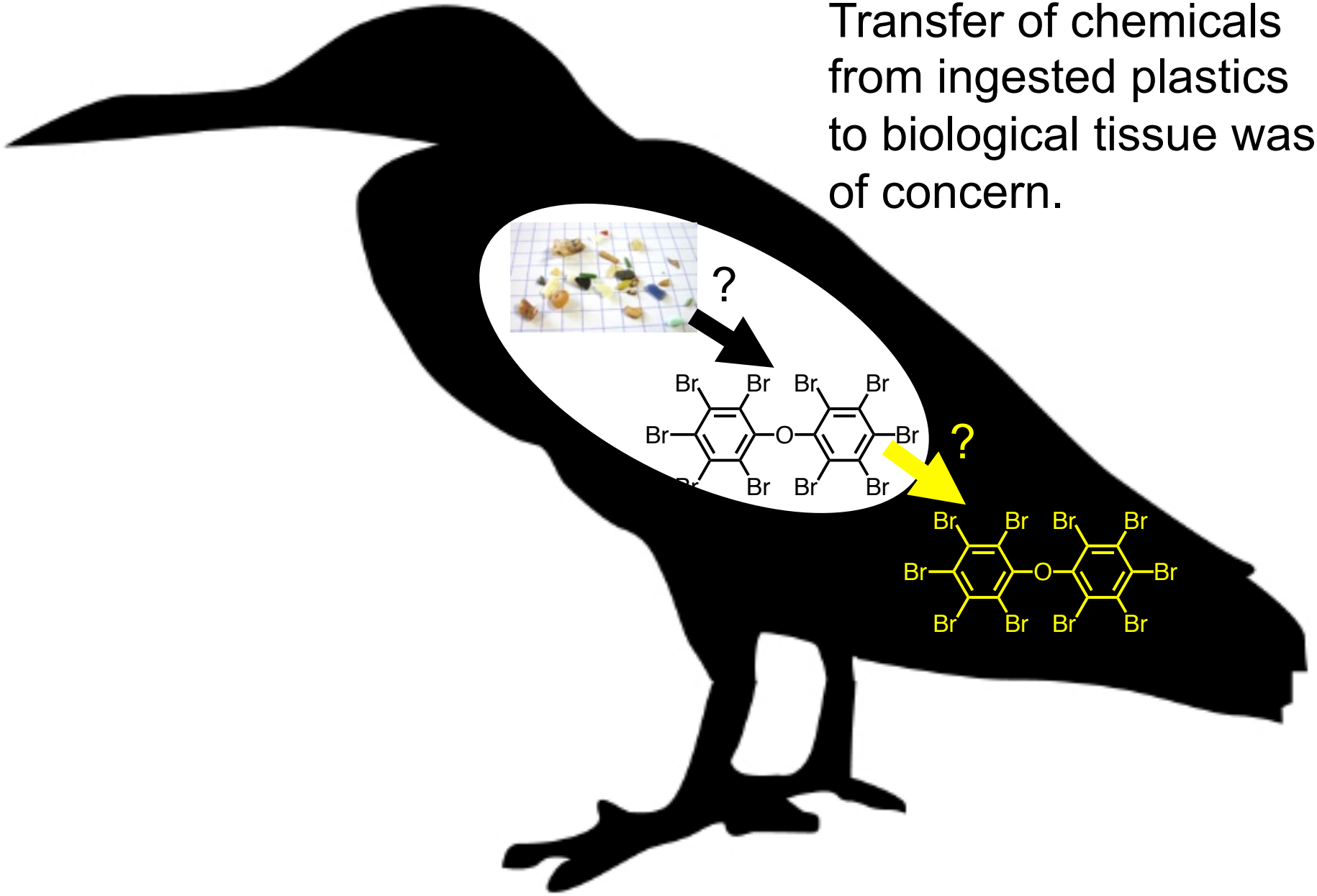


Bisphenol A

Transfer of chemicals from ingested plastics to biological tissue



Transfer of chemicals from ingested plastics to biological tissue was of concern.

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journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Edited by Bruce J. Richardson

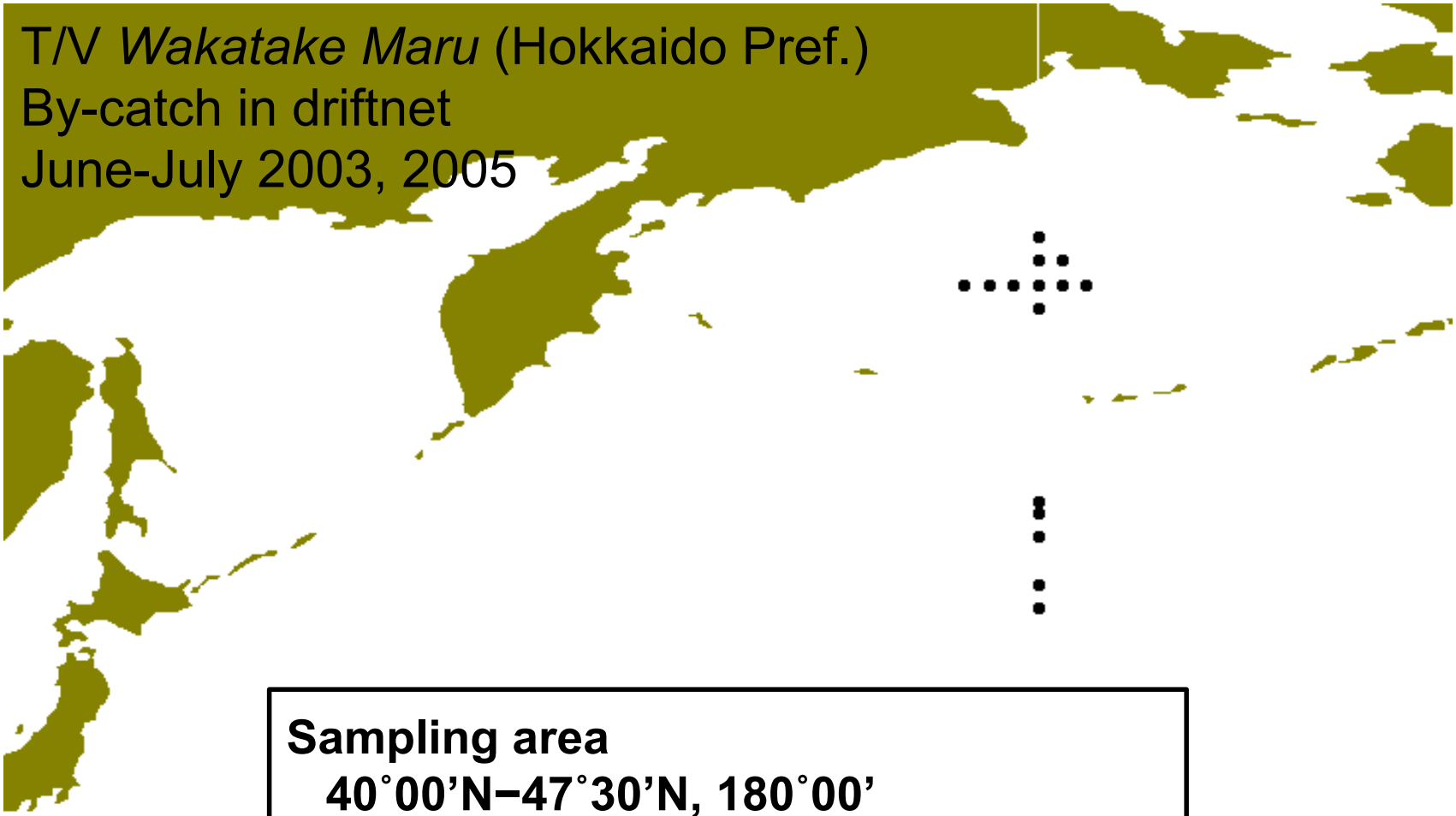
The objective of BASELINE is to publish short communications on different aspects of pollution of the marine environment. Only those papers which clearly identify the quality of the data will be considered for publication. Contributors to Baseline should refer to 'Baseline—The New Format and Content' (*Mar. Pollut. Bull.* **60**, 1–2).

Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, *Puffinus tenuirostris*, in the North Pacific Ocean

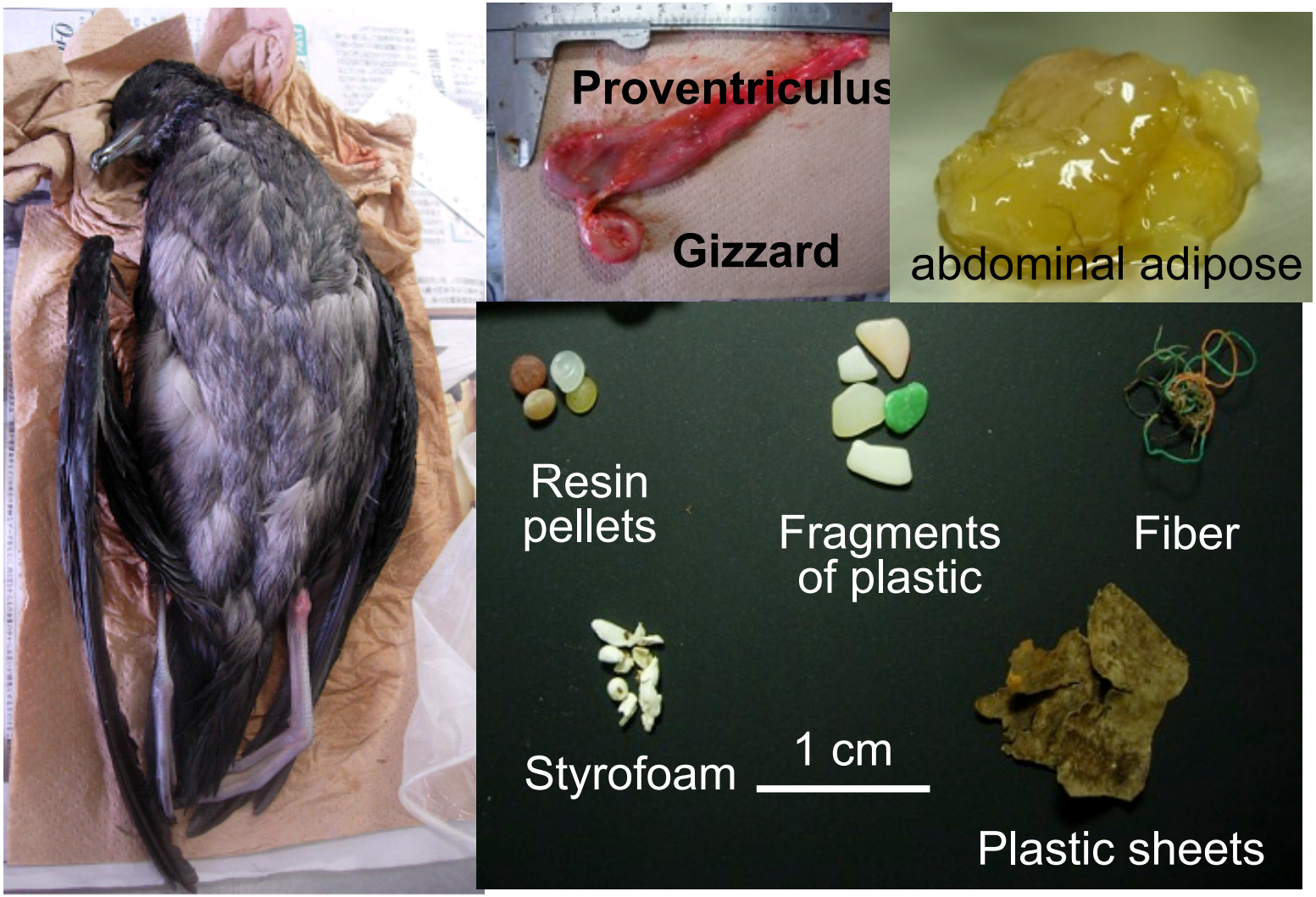
Rei Yamashita [a,c,*], Hideshige Takada [a], Masa-aki Fukuwaka [b], Yutaka Watanuki [c]

[a] *Laboratory of Organic Geochemistry (LOG), Tokyo University of Agriculture and Technology, Fuchu, Tokyo 183-8509, Japan*
[b] *Hokkaido National Fisheries Research Institute, Fisheries Research Agency (FRA), 116 Katsurakoi, Kushiro, Hokkaido 085-0802, Japan*
[c] *Graduate School of Fisheries Sciences, Hokkaido University, 3-3-1 Minato, Hakodate 041-8611, Japan*

Short-tailed shearwater from Northern pacific



Abdominal adipose of circus of short-tailed shearwater by-catch



- Amount of plastics found in stomach
- PBDEs concentrations in abdominal adipose

Increased pollutants concentrations with increasing plastic ingestion

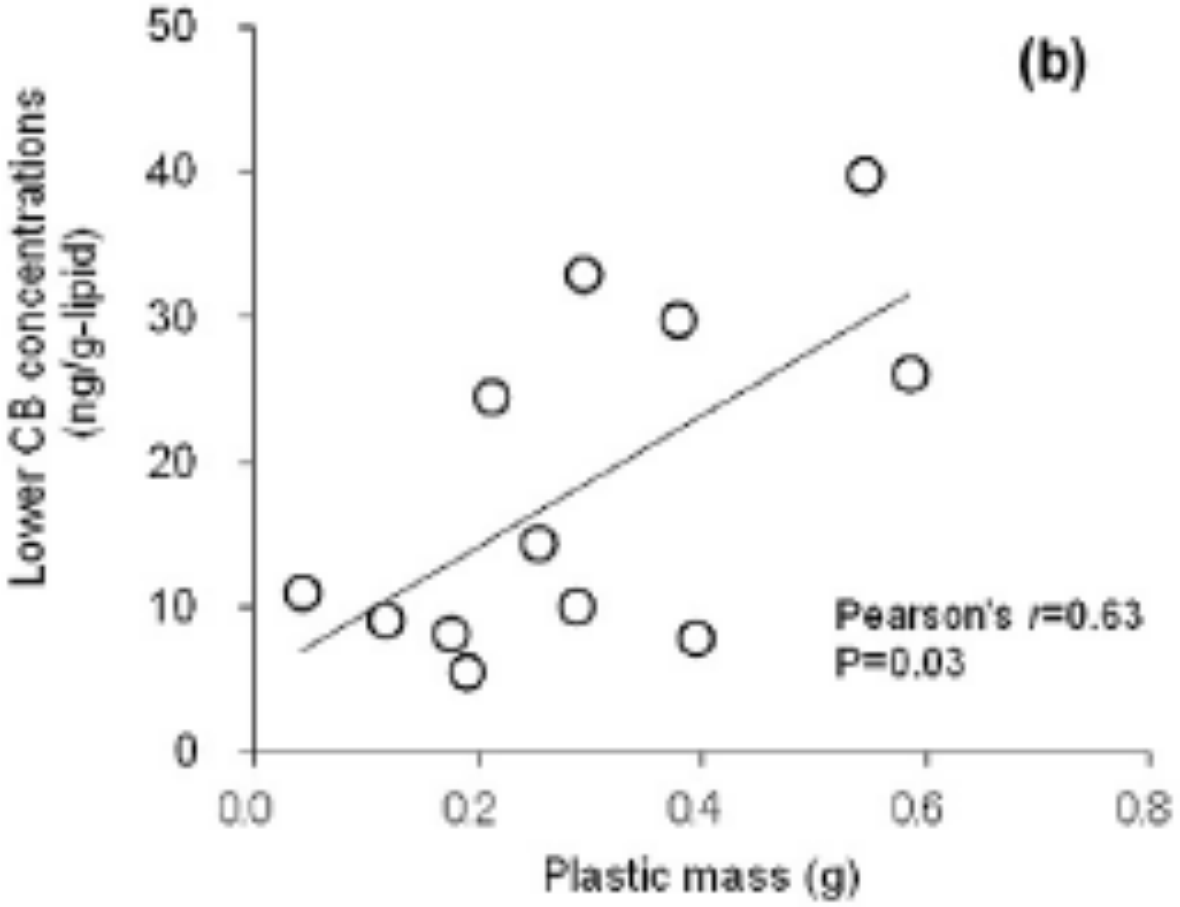
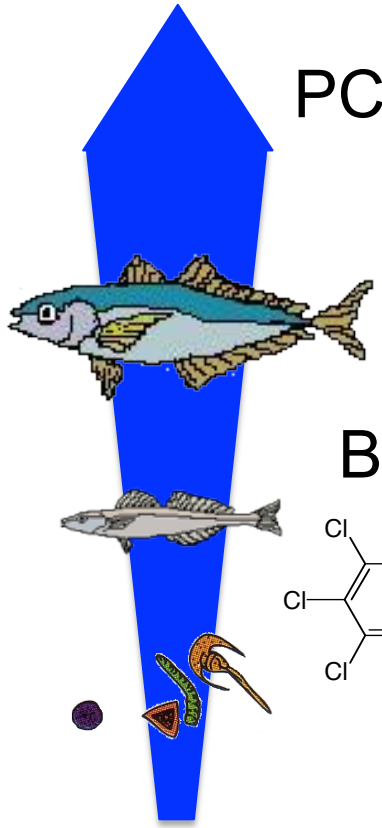


Fig. 4. Relationships between ingested plastic mass and concentrations of (a) total PCBs, (b) lower-chlorinated congeners (Cl number 2–4, see Fig. 3), and (c) higher-chlorinated congeners (Cl number 5–9, see Fig. 3) in abdominal adipose tissues of shearwaters that ingested plastics.

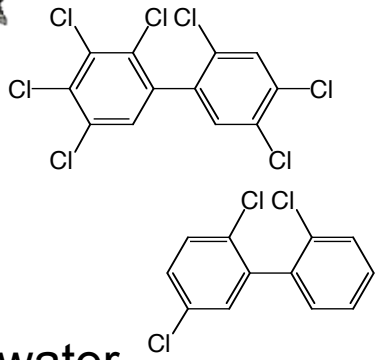
Exposure of contaminants both from plastics and prey

Plastic-derived PCBs

PCBs from prey



Biomagnification

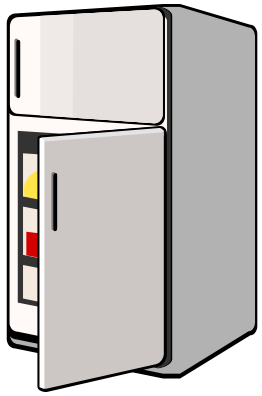


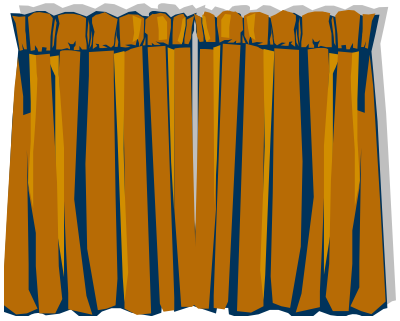
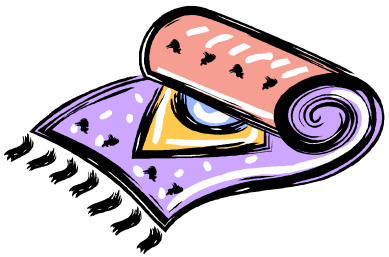
PCBs in seawater

Takada 2013 “Accumulation”

PBDEs : Flame retardants

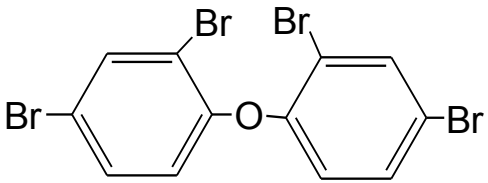
applied in various electric products and fabrics.




Lower brominated

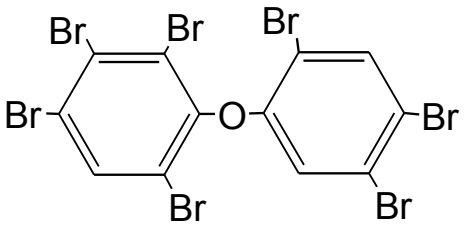
(Br4, Br5)



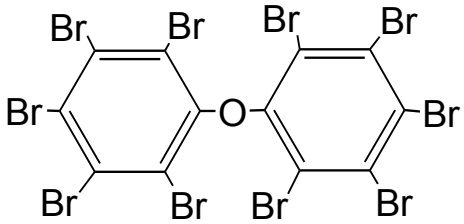
BDE47

Higher brominated

(Br7 - 10)



BDE183

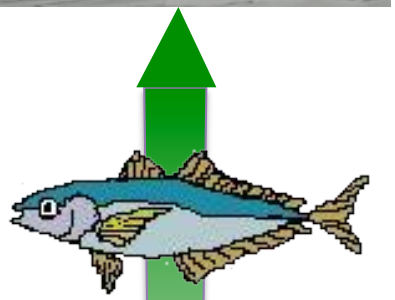


BDE209

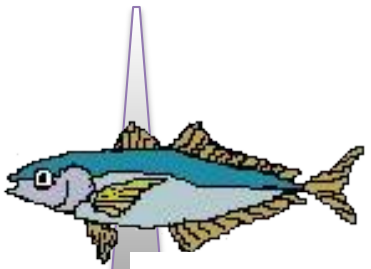
Plastic-derived Higher brominated congeners could have more impact on exposure of the contaminants to oceanic seabird

Lower brominated congeners (Br_1 – Br_6)

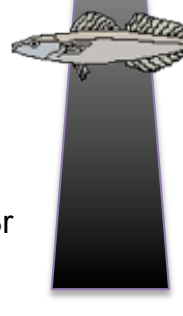
Higher brominated congeners (Br_7 – Br_{10})

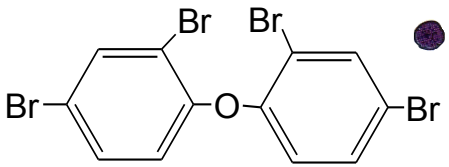


Less biomagnified

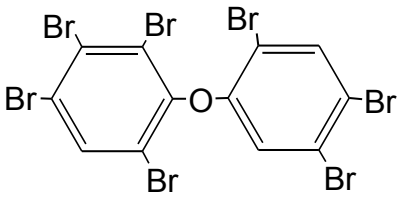


No detection in pelagic fish

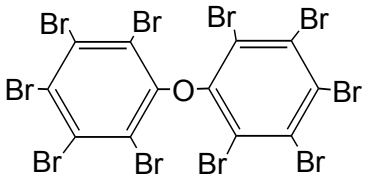




BDE47

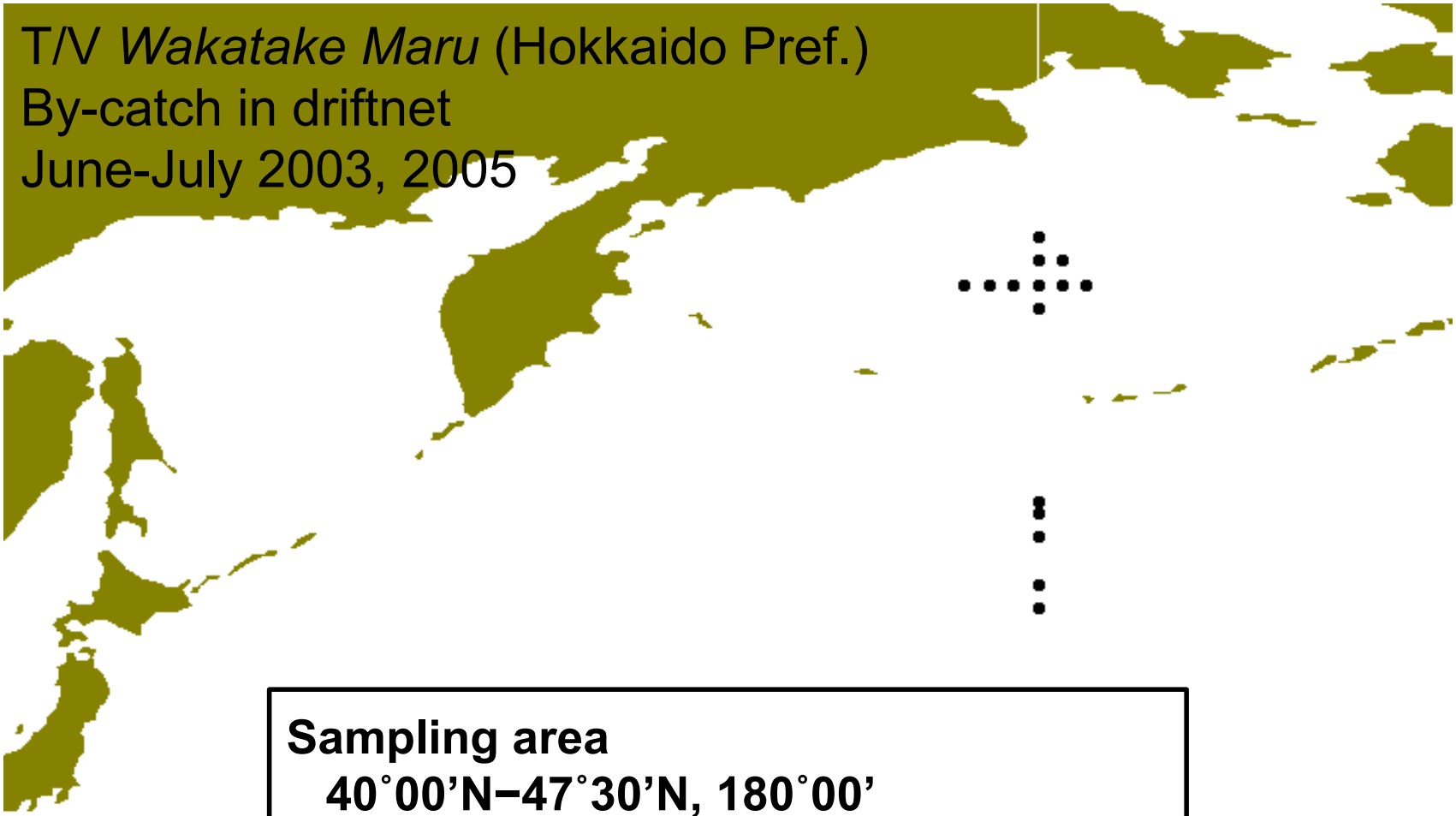


BDE183

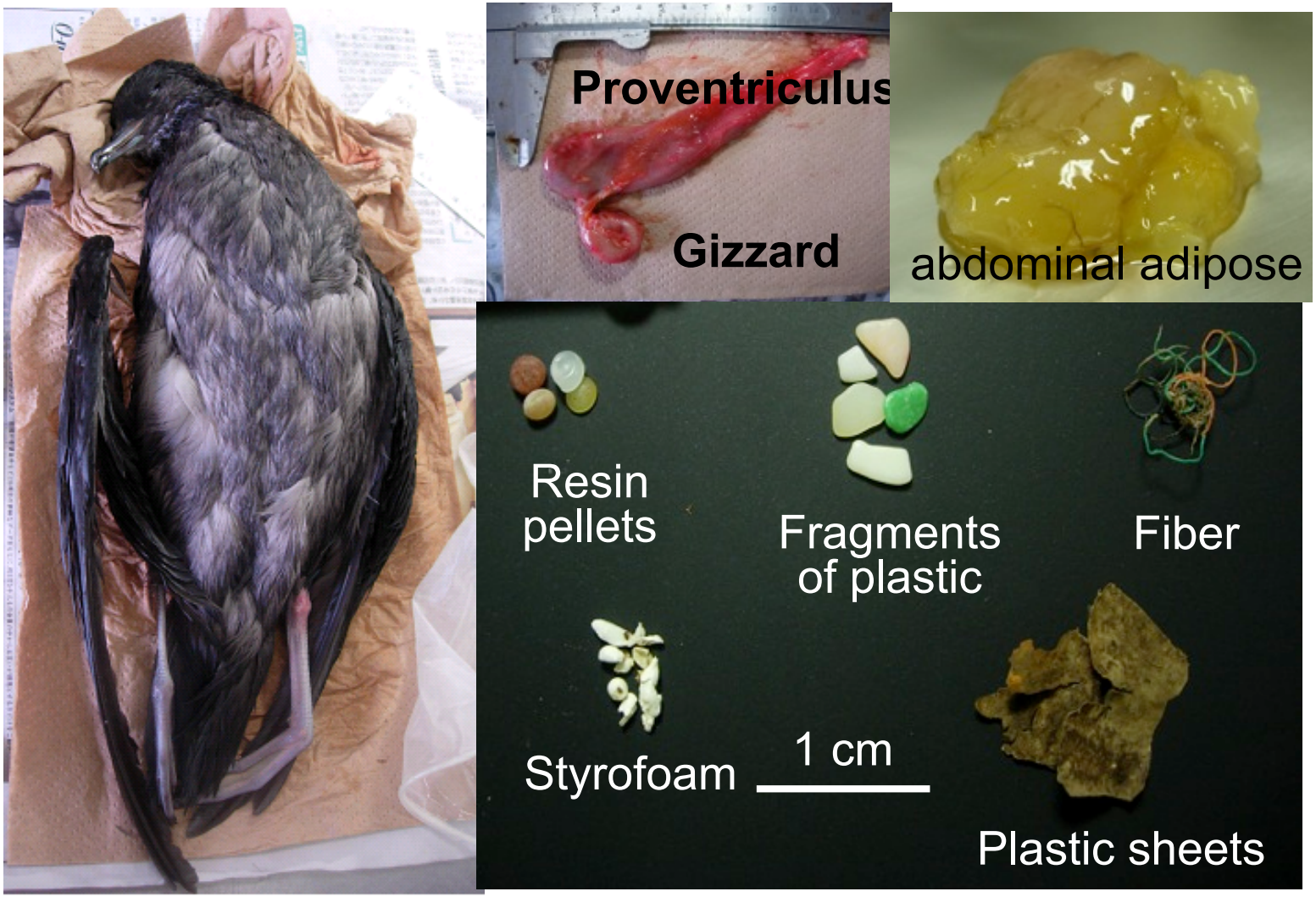


BDE209

Short-tailed shearwater from Northern pacific

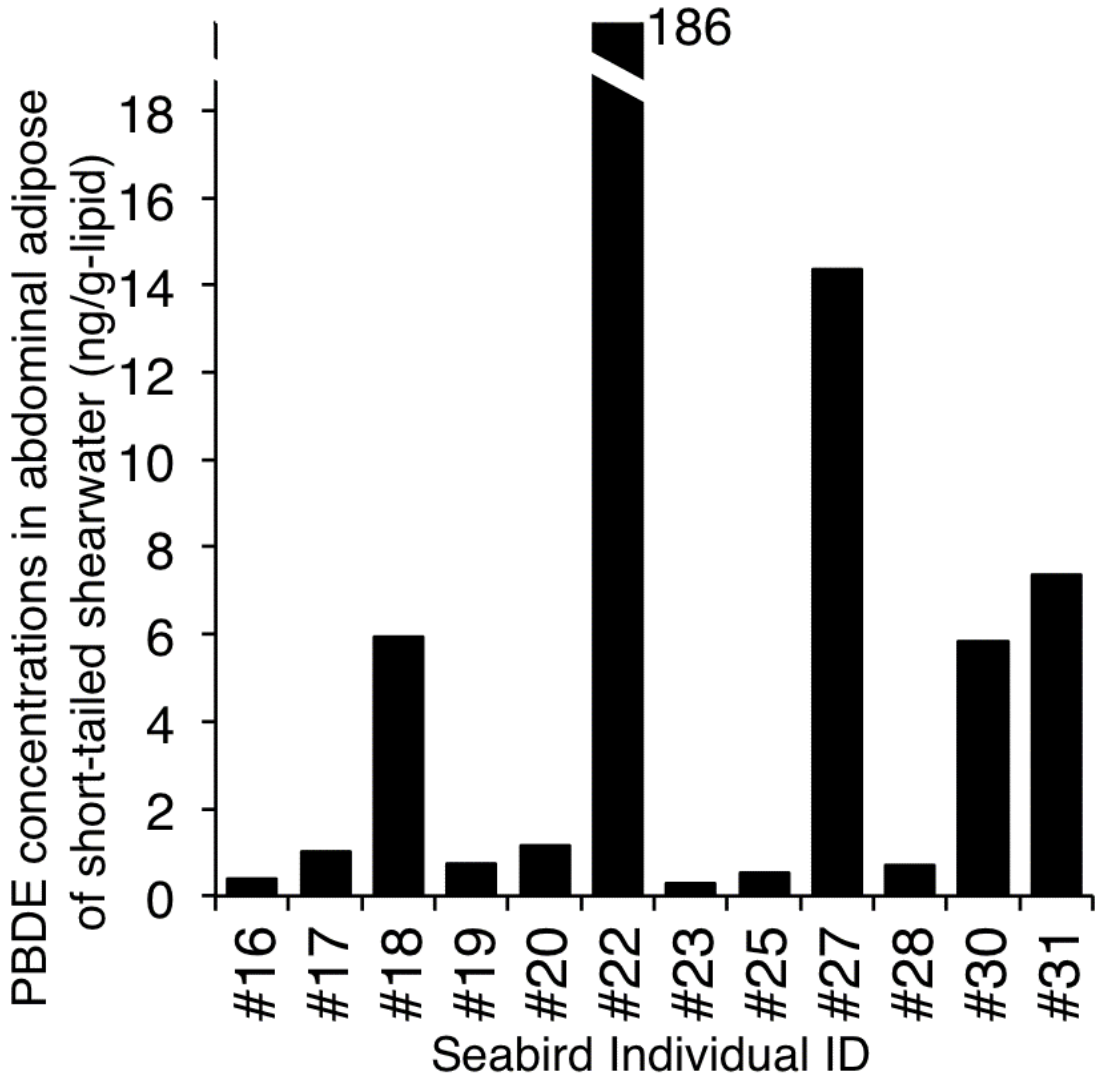


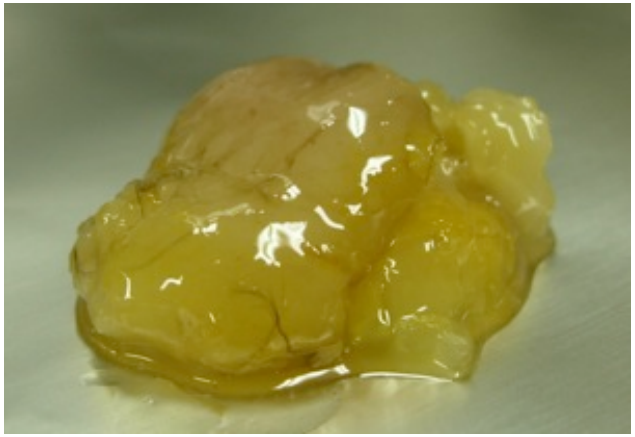
Abdominal adipose of circus of short-tailed shearwater by-catch



- Amount of plastics found in stomach
- PBDEs concentrations in abdominal adipose

Higher concentrations of PBDEs were detected sporadically in fatty tissue of the seabird



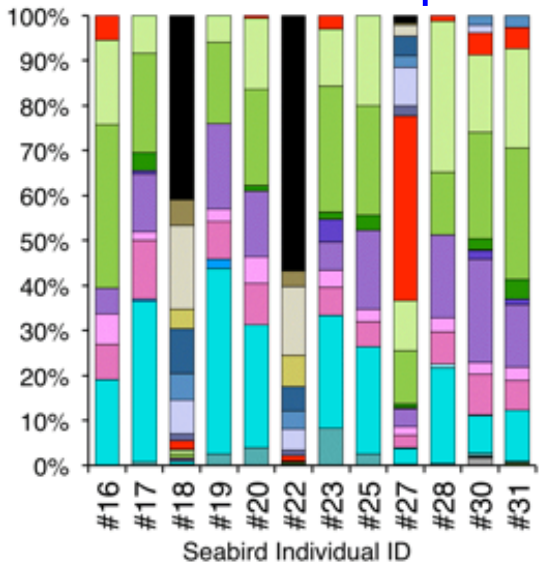


PBDEs were detected in abdominal adipose of all the individuals.

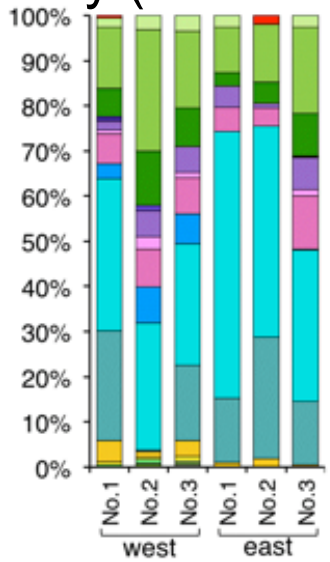
Blank
BDE#47 : 0.0006 ng/g-lipid
BDE#209 :0.03 ng/g-lipid

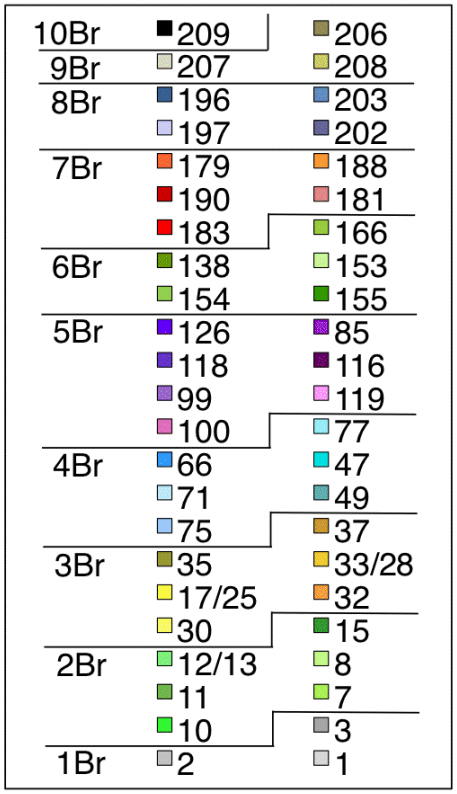
Composition of BDE congeners in seabird adipose, plastics in the stomachs, and their prey.

Abdominal adipose

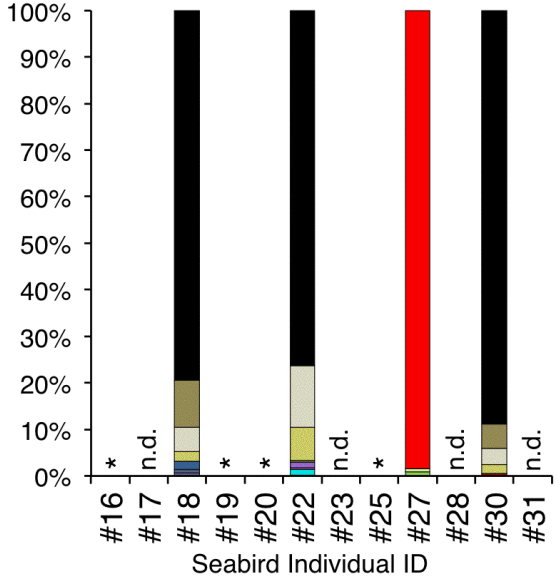


Prey (lantern-fish)



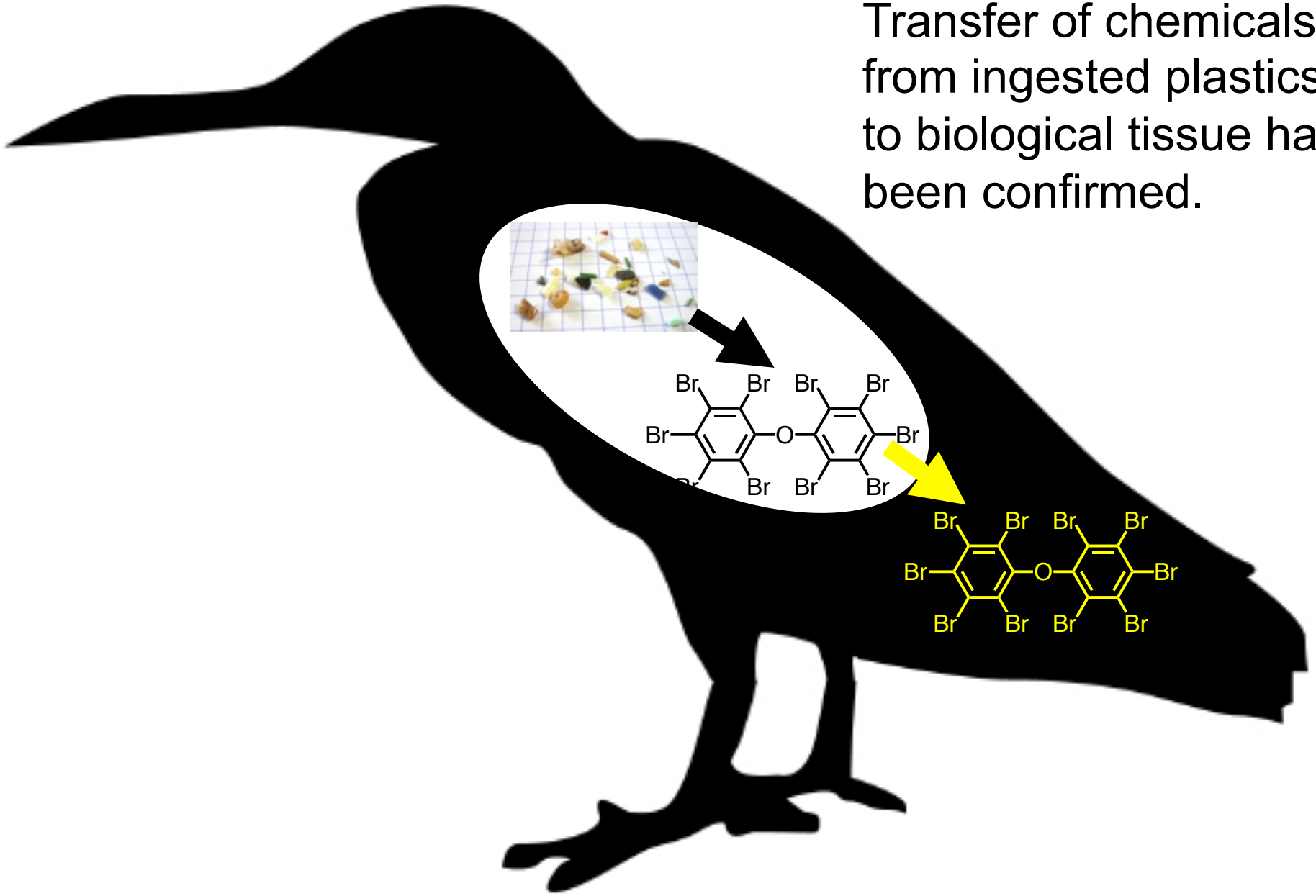


Plastics in stomach



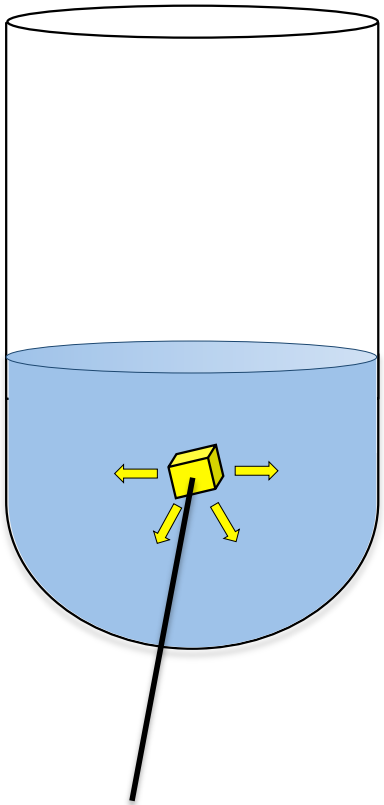
Higher brominated congeners were derived from ingested plastics, whereas lower brominated congeners were derived from natural prey

Transfer of chemicals from ingested plastics to biological tissue



Transfer of chemicals from ingested plastics to biological tissue has been confirmed.

Leaching experiment to test bioavailability of additives in plastic



BDE209 was industrially compounded into polyethlene (PE)

Distilled water

Sea water

Pepsin solution 20°C

Pepsin solution 38°C

Fish oil from walleye pollack,

Stomach oil

collected from Streaked Shearwater

Conclusion and Questions to be addressed

Conclusions

Transfer of the chemicals from ingested plastics to internal system of the biota was confirmed for a species of seabird.

Questions

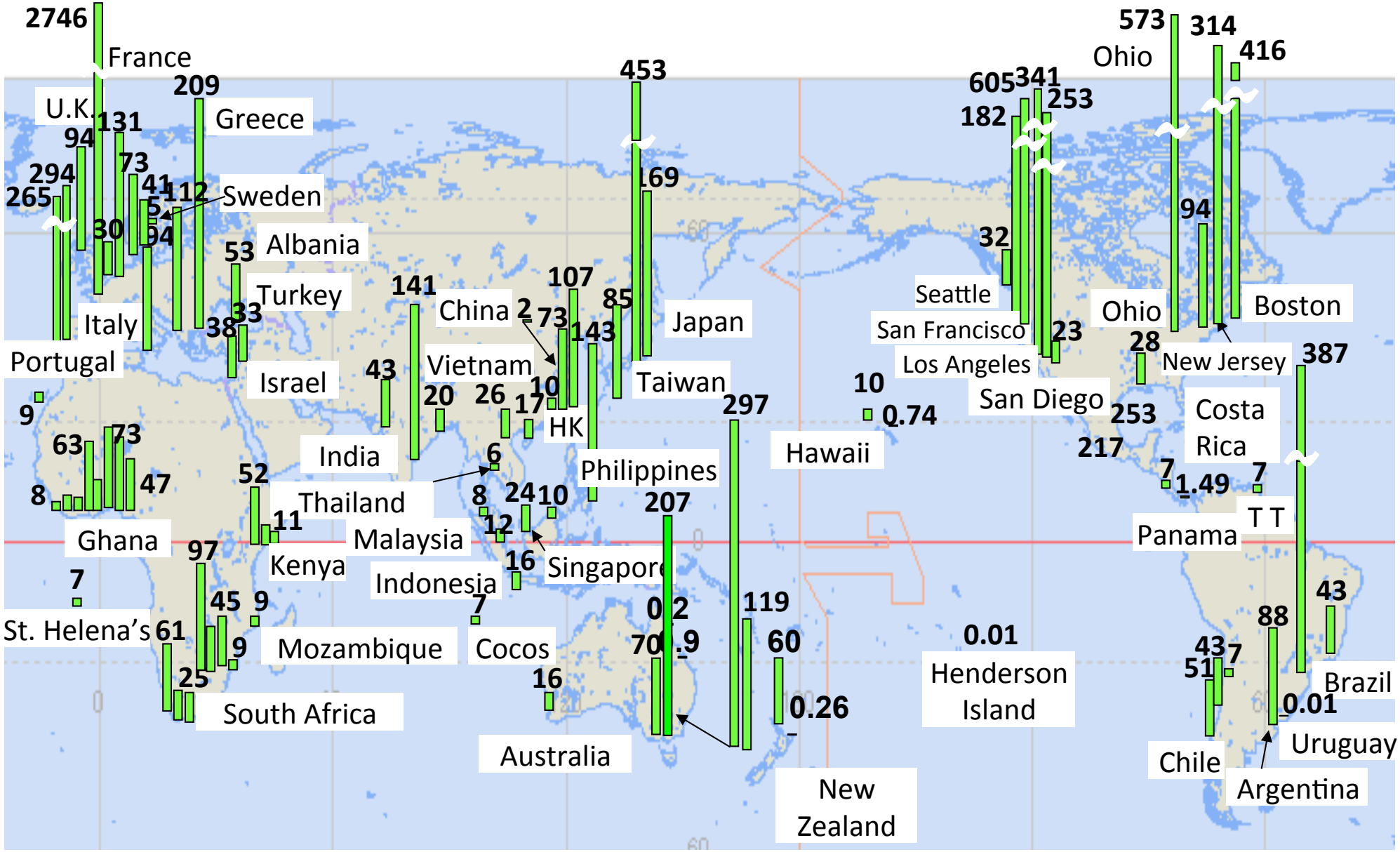
Magnitude of the plastic-associated transfer of chemicals.

The other areas? The other species?

The other animals?

Biological response (adverse effects on the marine organisms)

Call for pellets from PICES member countries!



Concentration of PCBs* in beached plastic resin pellet (ng/g-pellet)